at this time the patient was not in a suitable condition to react properly to the von Noorden diet.

To study this point further, another series of observations was made later. On June 23, after the patient for two months had been allowed a diet restricted only in carbohydrates, he was placed on a standard test diet of known composition. This test diet was mainly to determine his capacity for oxidizing carbohydrate and of combating acidosis. At this time his general condition was unfavorable, the sugar elimination increased, and the signs of acidosis were marked. It will be seen from Table II and Chart II that he was using practically none of the carbohydrate in the food, and further, that a rather severe acidosis was present. The course of the dietary changes, with the urinary analyses from day to day, may be seen in detail in the table, and may be summarized in the statement that *the use of fresh vegetables and the von Noorden gruel resulted in raising strikingly the patient's tolerance for carbohydrates and in reducing considerably the degree of acidosis.*

It is also noted in Table II that there was a wide variation in the ammonia output, which diminished during the vegetable and oatmeal days and reached a higher point when the diet contained little or no carbohydrate.

In conclusion, it can be said that these two cases of traumatic diabetes ran a milder course than is usually seen in diabetes in children, but otherwise in their urinary and therapeutic reaction they did not differ essentially from cases of diabetes of non-traumatic origin.

BIOT'S BREATHING.

By Lewis A. Conner, M.D.,

PROFESSOR OF CLINICAL MEDICINE IN THE CORNELL UNIVERSITY MEDICAL COLLEGE; PHYSICIAN TO THE NEW YORK HOSPITAL.

(From the Medical Service of the New York Hospital.)

In 1876, Camille Biot[1] published a study of Cheyne-Stokes respiration, and in a postscript to the article he reproduces two pneumatographic tracings, taken from a boy, aged sixteen years, suffering from tuberculous meningitis, and comments upon these as follows: "Now these traces differ notably from those of Plate 1, Cheyne-Stokes breathing, especially in that before and after the pause there are no respiratory movements of a gradually increasing and diminishing sort, but instead a respiration which is usually deep and dyspnœic, corresponding to a deep sigh made by the patient at such times;" and later he adds: "Without wishing to draw definite conclusions from a single case, it seems, nevertheless, that in meningitis there exists not the true type of Cheyne-Stokes, but a type more or less related, more or less regular."

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[1] Contribution a l'étude du phénomène respiratoire de Cheyne-Stokes. Lyon médical, 1876, xxiii, 517 and 561.

Two years later in a monograph[2] embodying further experimental and clinical study of Cheyne-Stokes breathing, he devotes a chapter to "le rythme méningitique." He quotes from a number of authoritative writers, among them Grisolle, Trousseau, and Jaccoud, to show that the characteristic respiration of meningitis, especially of the tuberculous variety, while irregular, and marked by periods of apnœa, is still quite unlike the Cheyne-Stokes type. The pauses occur at irregular intervals, and are often preceded or followed by a deep sigh. There are lacking the gradual diminution and increase in the force of the respiratory movements before and after the apnœic periods. Shallow and deep, rapid and slow movements follow one another without any regularity or rule. He points out that the descriptions of both Cheyne and Stokes show that they had in mind a distinct and clean-cut clinical picture in which there is a regular succession of apnœic pauses and of periods of breathing of gradually increasing and decreasing force, and he protests against the tendency to include under the term Cheyne-Stokes respiration a type presenting so many points of difference from that described by these two astute Dublin clinicians. Biot, therefore, did not and did not profess to describe a new variety of pathological breathing. He merely emphasized the salient features of a type of breathing which had long been noted as occurring in meningitis and other cerebral disturbances, and contrasted these with those of the type described by Cheyne and Stokes.

It is somewhat strange that in the abundant literature relating to Cheyne-Stokes breathing that has accumulated since the writings of Biot, so little consideration has been given to the type of breathing to which he called attention, and which since that time has usually borne his name.

Aside from the casual mention of it as a variety of Cheyne-Stokes breathing in a few works on diagnosis, it is rarely referred to. Hofbauer, in his careful pneumatographic study[3] of the various types of dyspnœa, has evidently given the matter some attention, but his experience seems to have been unfortunate, for he dismisses the subject with the following words: "This form of breathing, so often described, I have never been able to find. Again and again when, upon simple inspection of the patient, I have thought that I had finally found a case of Biot's breathing, the graphic

[2] Etude clinique et expérimentale sur la respiration de Cheyne-Stokes, Paris, 1878.

[3] Semiologie und Differentialdiagnostik der verschiedenen Arten von Kurzatmigkeit auf Grund der Atemkurve, Jena, 1904, p. 27.

representation has shown me that it was after all Cheyne-Stokes breathing."

As far as I have been able to discover, no graphic representation of this type of breathing has ever been published, other than the original tracings of Biot, which are here reproduced (Fig. 1). In each of these the descending limb of the trace records the inspiratory rise of the chest; the ascending limb, the expiratory fall.

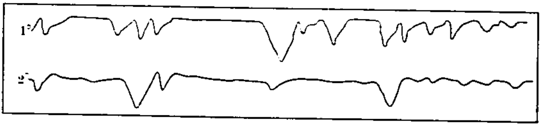

FIG. 1.—Copy of Biot's tracings illustrating the meningitic type of breathing. Down stroke = inspiration.

During the past two years, in the course of a more or less systematic graphic study of pathological types of breathing, I have encountered typical examples of Biot's type of respiration seven times. In six instances it occurred in the course of meningitis; in the seventh (Case VII), it was found in a child suffering from some intracranial complication of suppurative mastoiditis, the nature of which could not be determined.

The peculiarities of this type of respiration are well illustrated in the tracings shown in Figs. 2 and 3. The tracings obtained in all the other cases were in every respect similar to those here shown, so that it has not seemed worth while to reproduce tracings from every case.

The tracings were obtained by means of two pneumatographs of the Marey type, one placed about the thorax at the level of the third rib, to record the movements of the upper thorax; the other placed about the abdomen, midway between the ensiform and the umbilicus, to register the movements of the diaphragm. In each figure, the upper trace represents the movements of the thorax; the lower, those of the diaphragm. The descending limb of the trace indicates the inspiratory movement. The bottom line records the time in seconds.

CHARACTERISTICS OF BIOT'S BREATHING. The characteristic features of this form of respiratory arrhythmia may be stated as follows:

1. Periods of apnœa, which vary in length and occur at irregular intervals.
2. Constant irregularity in rhythm, and in the force of the individual respirations.
3. The frequent occurrence of deep sighs.

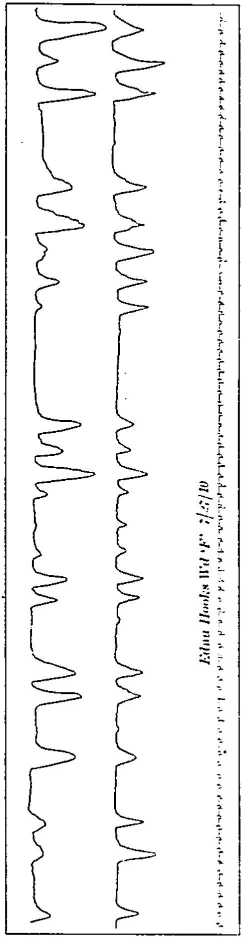

Fig. 2.—Respiratory tracing from a case of tuberculous meningitis, showing Biot's breathing.

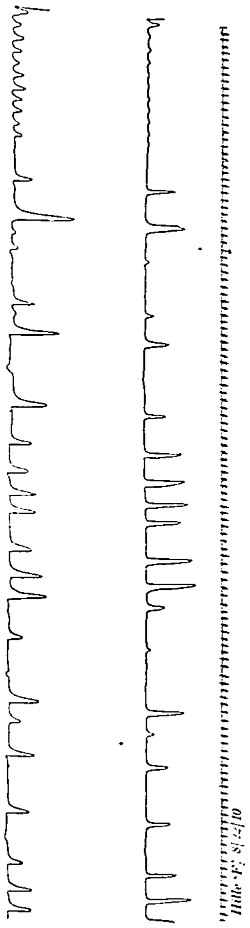

Fig. 3.—Respiratory tracing from a case of tuberculous meningitis, showing Biot's breathing.

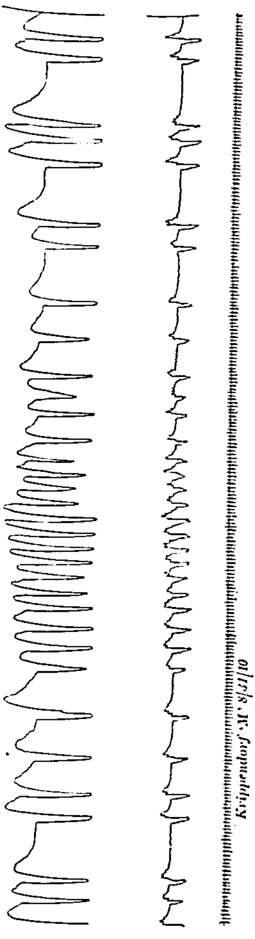

Fig. 4.—Respiratory tracing from a case of fatal anuria.

4. In addition to the above well-recognized features, I wish to mention one which in all of my tracings was so constant and striking as to seem to warrant its inclusion among the cardinal features of the condition. I refer to the great uniformity of the expiratory level. In spite of the constant variation in the depth of inspiration, the corresponding expiratory movement always carried the writing lever back to the same uniform level, so that the top of the trace formed a straight, horizontal line. This peculiarity seems to be due to the fact that the expiratory act is purely a passive one, and that the active, muscular expiration, so frequently seen in various types of respiratory disturbances, is altogether lacking.

This feature is well brought out by comparing the tracings of Figs. 2 and 3 with those of Fig. 4. These last were taken from a case of fatal anuria (Case VIII), the patient being in a condition of light stupor, and it will be seen that the ascending (expiratory) limb of the trace is always carried well above the mean expiratory level, as seen during the long pauses, and that the height of this expiratory rise varies with each respiration. These peculiarities are apparent in both the thoracic and the abdominal traces, and are the result of active, muscular expiratory efforts of both chest and abdomen.

This type of breathing corresponds in many respects with Biot's meningitic type: there are the apnœic pauses coming at irregular intervals, the constant variation in rhythm, and the constant, if slight, variation in amplitude. It differs, however, in the absence of the deep, sighing respirations, and especially in the markedly active character of the expiration; and I am inclined to believe that future study may show it to have a different pathogenesis, and justify its classification as a separate type of respiratory arrhythmia.

OCCURRENCE OF BIOT'S BREATHING. From the scanty information obtainable from the literature of the subject, it is evident that Biot's type of respiration has been supposed to occur not only in meningitis, but in other cerebral conditions as well. It is sometimes referred to as "cerebral breathing." No very definite statements upon this point, however, are to be found. Of the seven typical examples of this form of breathing among my own cases, 6 were proved to be cases of meningitis and the seventh (Case VII) may have been one, although this could not be proved. In the 24 other cases of meningitis studied, Biot's breathing was never detected. In other words, it was noticed in only about 20 per cent. of the cases observed.

In three instances it occurred in infants of two years or under; twice in children of eight years of age, and twice in adults. Of the 6 proved cases of meningitis 4 were of the tuberculous type, 1 was caused by Streptococcus pyogenes and 1 by Diplococcus intracellularis. Among a great variety of other diseases studied, including a number of cerebral conditions, such as hemorrhage, thrombosis, cerebral lues, etc., and various forms of coma, no instance of this type of breathing was found.

By referring to the condensed case reports it will be seen that when this type of breathing appeared it usually persisted through the greater part of the illness. In Case I it was observed almost daily through a period of five weeks. In four of the cases the irregularity was noticed upon admission to the hospital, only a few days after the onset of symptoms; so there can be no question that this respiratory arrhythmia may sometimes be an early, and therefore an important, sign of meningitis. Its occurrence seemed to bear no special relation to the state of the pulse (whether rapid, slow or irregular), or indeed to the presence or absence of any other symptom. It was seen in deep coma, and in states of consciousness in which slight drowsiness and apathy was the only departures from the normal.

RELATIONSHIP TO CHEYNE-STOKES BREATHING. Biot was quite warranted, it seems to me, in insisting upon the sharp distinction between this meningitic type and the form of breathing described by Cheyne and Stokes. The two types have really little in common. The dominant feature of Cheyne-Stokes breathing is the rhythmic succession of periods of apnœa and periods of dyspnœa. The apnœic pauses in any given case are quite uniform in length and occur at regular intervals. The periods of dyspnœa are all composed of about the same number of respirations and show regularly a progressive waxing and waning in the force of the respirations. The characteristic feature of Biot's type on the other hand, is its complete lack of any sort of rhythm. The periods of apnœa vary in length and occur at irregular intervals and there is constant irregularity in both the rate and the force of the individual respirations. Such essentially different types of breathing must, it seems to me, have a different cause and pathogenesis. Among the cases here reported well-marked Cheyne-Stokes breathing was observed only once. In this case it replaced Biot's type during the last two or three days of life. In two other cases a slight suggestion of the Cheyne-Stokes rhythm was observed in the tracings on two or three occasions during the intervals when the breathing was, in other respects, normal. In Case I, in which tracings were taken almost daily over a period of five weeks, the Cheyne-Stokes type was never encountered. The fact that Cheyne-Stokes respiration is occasionally seen in patients who, at other times, show Biot's type only means, I think, that in such patients the intracranial conditions of—let us say—pressure or irritation are changing.

PATHOGENESIS. Concerning the pathogenesis of Biot's meningitic type of breathing there is little to say, since almost nothing is known. The only suggestion of an explanation that I have found is that ventured by G. A. Gibson[4] in his comprehensive historical and critical study of Cheyne-Stokes respiration. Accepting the conclusions of Marckwald that periodic breathing can only occur when some of the higher brain tracts have ceased to exert their influence upon the automatic centre in the medulla, he suggests that true Cheyne-Stokes breathing may require the total abolition of such higher brain influences and that the meningitic or cerebral type may result from "the irregular discharge of unequal impulses" from such higher tracts.

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[4] Cheyne-Stokes Respiration, Edinburgh, 1892, p. 126.

The inhibitory effect, upon respiration, of stimulation of the various sensory nerves is well known, and Marckwald[5] has shown that this is preëminently true for the glossopharyngeal, which he refers to as "a true inhibitory nerve of respiration," coming into action, however, only under exceptional circumstances, as for example, during the inhibitory mechanism of swallowing. When this nerve is stimulated there is complete cessation of respiration for a short time and then breathing is resumed even though the stimulation of the nerve be continued. It has occurred to me that the peculiarities of Biot's breathing may possibly be explained by assuming an involvement of the root of the glossopharyngeal nerve in the meningitic inflammation, with resulting irritation of the nerve. This hypothesis is in line with the commonly accepted idea that many of the pulse irregularities of meningitis result from irritation of the vagus root. Thus far I have had no opportunity to examine, postmortem, the condition of the cranial nerve roots in cases which had shown this type of breathing. If such an hypothesis be correct we might reasonably expect to find Biot's breathing especially common in the epidemic type of meningitis, in which there seems to be an especial tendency toward involvement of the nerve roots. It was present in the only case of that form of meningitis that I have had an opportunity to study graphically.

A synopsis of the histories of the cases which form the basis of this paper is as follows:

CASE I.—Man, aged thirty-eight years. No. 18,798. Admitted to the hospital September 18, 1909; died November 13, 1909. Eight days before, while in good health, he had undergone some operation upon the nose and a few hours later had developed backache, headache, fever, and vomiting. Since then fever, severe headache, and increasing stupor. On admission stupor, rigidity and tenderness of neck, unequal pupils and paresis of right side of face and right arm and leg. The turbid spinal fluid, obtained on several occasions, always yielded a pure growth of Streptococcus pyogenes.

The disease ran a subacute course with periods of marked remission in the symptoms. Much of the time the patient was conscious and fairly comfortable. Distinct irregularity of the breathing was first noted on October 9, and was present most of the time up to his death on November 13. The heart action remained regular to the end. A pronounced diuresis was noted through the greater part of the illness. Two days before death he developed a right-sided pneumothorax, presumably as a result of an aspiration pneumonia, but even after this the breathing retained its characteristic irregularity. Many pneumatographic tracings were taken between October 9 and November 13. Most of these presented all the characteristic features of Biot's breathing, that is, variations in rhythm and force, occasional deep sighing respirations, and periods of apnœa varying in length and occurring at irregular intervals. Occasionally during periods of temporary improvement, the breathing would be quite normal. At no time was the respiration of the Cheyne-Stokes type.

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[5] The Movements of Respiration, London, 1888, p. 90.

CASE II.—Girl, aged eight years. No. 20,072. Admitted July 15; died August 3, 1910. Illness began four days before admission, with headache which grew very severe. Later vomiting, fever, drowsiness, nocturnal delirium, rigidity of the neck, slight Kernig's sign, strabismus, coma, and death on November 3. Tubercle bacilli were found in the spinal fluid. Respiratory irregularity was first noted on July 23.

On July 26, 27, and 28, tracings showed typical Biot's breathing (Fig. 2). July 29, breathing much more rapid and more regular, but tracings show short periods of apnœa and some variation in rhythm and force. July 30, tracings are suggestive of infantile type of Cheyne-Stokes. July 31, typical Biot's breathing.

August 1. Tracings suggestive of Cheyne-Stokes.

August 2. Breathing rapid and almost regular in rhythm and force.

August 3. (Moribund) breathing very rapid and regular.

CASE III.—Male child, aged fourteen months. No. 20,267. Admitted August 18; died August 27, 1910. Illness began abruptly five days before admission, with general convulsions, vomiting, diarrhœa, and fever. Later drowsiness, stiff neck, retraction of head, stupor, and ultimately coma. Tubercle bacilli were found in spinal fluid. On admission it was found that the respiration was irregular in rhythm and depth and showed long apnœic pauses.

August 22. Tracings showed typical Biot's breathing (Fig. 3).

August 23. Breathing rapid and fairly regular most of time.

August 24. Tracings suggestive of Biot's type, but with no deep sighs and no long pauses.

August 25 and 26. Tracings similar to those of August 24.

August 27. (Moribund) breathing very rapid and almost perfectly regular.

CASE IV.—Male child, aged twenty-one months. No. 20,337. Admitted August 31; died September 10, 1910. Well up to six days before admission; then developed alternating drowsiness and restlessness. Later fever, twitching of limbs and head, and rolling of eyes. On admission the child was stuporous, the neck was slightly stiff, eyes constantly moving from side to side. Well-marked bilateral Kernig's sign. Respiration was "shallow and irregular, with no long pauses." On September 2, several general convulsions. Comatose during last few days of life.

The spinal fluid was clear and sterile on culture. Examinations for tubercle bacilli were negative, but fluid injected into a guinea-pig resulted in tuberculosis to the animal. Tracings taken every day between September 1 and 6, showed typical Biot's breathing each time. On September 7 and 8, however, the tracings showed distinct Cheyne-Stokes breathing of the infantile type.

CASE V.—Boy, aged eight years. No. 20,708. Admitted November 10; died November 25, 1910. One month before admission a large, red, and tender swelling appeared in left axilla which was opened and discharged pus. Two weeks later illness began with persistent frontal headache. Four days before admission went to bed and has since had headache, fever, restlessness, twitching of hands, rolling of eyes, and nocturnal delirium. On admission neck stiff and tender; marked bilateral Kernig's sign; conjugate deviation of eyes. Breathing was irregular, with long periods of apnœa. During last few days of life, stupor deepening into coma. Tubercle bacilli found in spinal fluid. During the first two days the twitchings of limbs and body were so constant as to make it impossible to obtain satisfactory tracings of the respiratory movements. After that the tracings usually showed distinctly Biot's type of irregularity. Occasionally the breathing would be almost perfectly regular; occasionally, too, the tracing would show a tendency to the Cheyne-Stokes type. During the last two days of life the respirations were very rapid and regular.

CASE VI.—Colored woman, aged nineteen years. No. 20,887. Admitted December 16, 1910. In good health up to time of present illness. Sudden onset one week before admission, with severe headache and backache. Headache constant day and night. For past two days has been delirious, has had stiffness of neck and has vomited frequently. On admission, patient had high fever, stiffness, and tenderness of neck, retraction of head, unequal pupils. The breathing was irregular in depth and rate, and showed long apnœic pauses. Pulse rapid and somewhat irregular. The cloudy spinal fluid was under high pressure and was increased in amount. It contained an increased number of both mononuclear and polynuclear cells. Smears showed a few Gram-negative intracellular diplococci, but no growth was obtained in the cultures. The severe symptoms persisted for several days, and then gradually subsided, the convalescence being complicated by an attack of erysipelas. Tracings taken on December 20 and 21 showed typical Biot's breathing.

CASE VII.—Female child, aged two years. No. 20,719. Admitted November 14, 1910. Discharge from left ear since an attack of measles some months before. Illness began four days before admission, with fever and vomiting. Has been listless and apathetic, restless at night, and has vomited frequently. On admission child was dull, the pupils were equal and reacted normally. No stiffness nor tenderness of neck, no paralysis, normal reflexes, no Kernig's sign. Temperature, 99 to 101. On November 18 patient had become stuperous, right pupil larger than left, paralysis of left facial nerve, tenderness over mastoid region, slight papillitis of both eyes. Tracings showed well-marked Biot's breathing. Examination of spinal fluid negative. The child was operated upon, and a suppurative mastoiditis found. No thrombosis of lateral sinus. Exploration failed to reveal a brain abscess. Death; no autopsy.

CASE VIII.—Married woman, aged twenty-nine years. No. 40,593. (Service of Dr. Bolton.) Admitted August 16; died September 3, 1910. For two years pain in left loin, with bloody urine. For three months has been passing "gravel" in urine. On August 22, operation on left kidney; several calculi found in pelvis; kidney removed. From then until the time of her death thirteen days later, the patient had practically complete anuria. She grew stuperous and finally comatose. Vomiting was persistent. Pulse slow and feeble. Blood pressure low. The respirations were slow and irregular and showed very marked active expiration. Tracings taken on several occasions always presented the same characteristic form (Fig. 4). An autopsy showed extensive cystic degeneration of the remaining kidney.

It is my pleasant duty to acknowledge my obligation, and to express my thanks, to Dr. R. G. Stillman for the very material help rendered by him in the work whose results are here recorded.

THE MYOGENIC DOCTRINE OF THE CARDIAC ACTIVITY AND ITS RELATION TO ARRHYTHMIA.

BY JOHN H. MUSSER, M.D.,
PROFESSOR OF CLINICAL MEDICINE IN THE UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA.

No portion of cardiac physiology and pathology has excited more interest and controversy than has the subject of arrhythmia or irregularity of the heart. Although most types of arrhythmia have long been recognized clinically, their true physiological significance and proper interpretation has been the result of a comparatively recent revolution in our views of the cardiac function. It may, therefore, be of some interest to take up certain of the more usual forms of cardiac irregularity from the standpoint of the modern physiology of the heart.

Before entering upon a discussion of the several forms of arrhythmia it will be of advantage to briefly consider certain facts in the physiology of the heart which are essential to a proper understanding of cardiac irregularity.

Scarcely more than a decade has elapsed since it was quite generally taught that the cardiac contraction was the result of a nerve impulse generated within the nervous system and conveyed to the heart muscle cells, the mechanism of which was not unlike that of voluntary skeletal muscle. Through the minute and painstaking physiological researches of Gaskill, Bowdich, especially of Engelmann, and others, this so-called neurogenic origin of the heart action was called into question and the view was advanced that the contraction stimulus develops within the cardiac muscle cell itself and is not dependent upon outside nervous agencies. This latter view has been called the myogenic doctrine, and with its advent the modern era of cardiac physiology may be said to have begun. It would be beyond the province of this paper to attempt to discuss the relative merits of the neurogenic and myogenic theories of the heart's contractions, concerning which so much dispute has arisen among the most eminent physiologists and clinicians. Suffice it to say, that, although today the question is far from being definitely settled, nevertheless, the weight of reliable embryological, anatomical, and physiological evidence tends largely to support the myogenic doctrine. It may be, as is suggested by Mackenzie, that the truth lies midway between these two opposing doctrines which may ultimately be reconciled. It is undeniable that in the fully developed mammalial heart there exists a complex nervous mechanism inseparably associated with the cardiac musculature. For this reason the writer hazards the belief that, although the chief seat of the cardiac stimulus is to be found within the muscle cells, the nervous system is employed by nature, in the heart, as is some of the secretory glands, as a "factory of safety." Certain glands will continue to secrete when entirely removed from all nerve influence, because of stimulation derived from chemical substances supplied from other glands. So, with the heart, it is possible that there are two modes by which cardiac action is maintained—either through the nervous system or through the heart muscle itself—and that this dual relationship affords a valuable factor of safety.

Briefly stated the myogenic theory assumes that the heart is an automatic organ, as it were, in which the stimulus that causes the contraction is generated within the heart muscle cells and is not